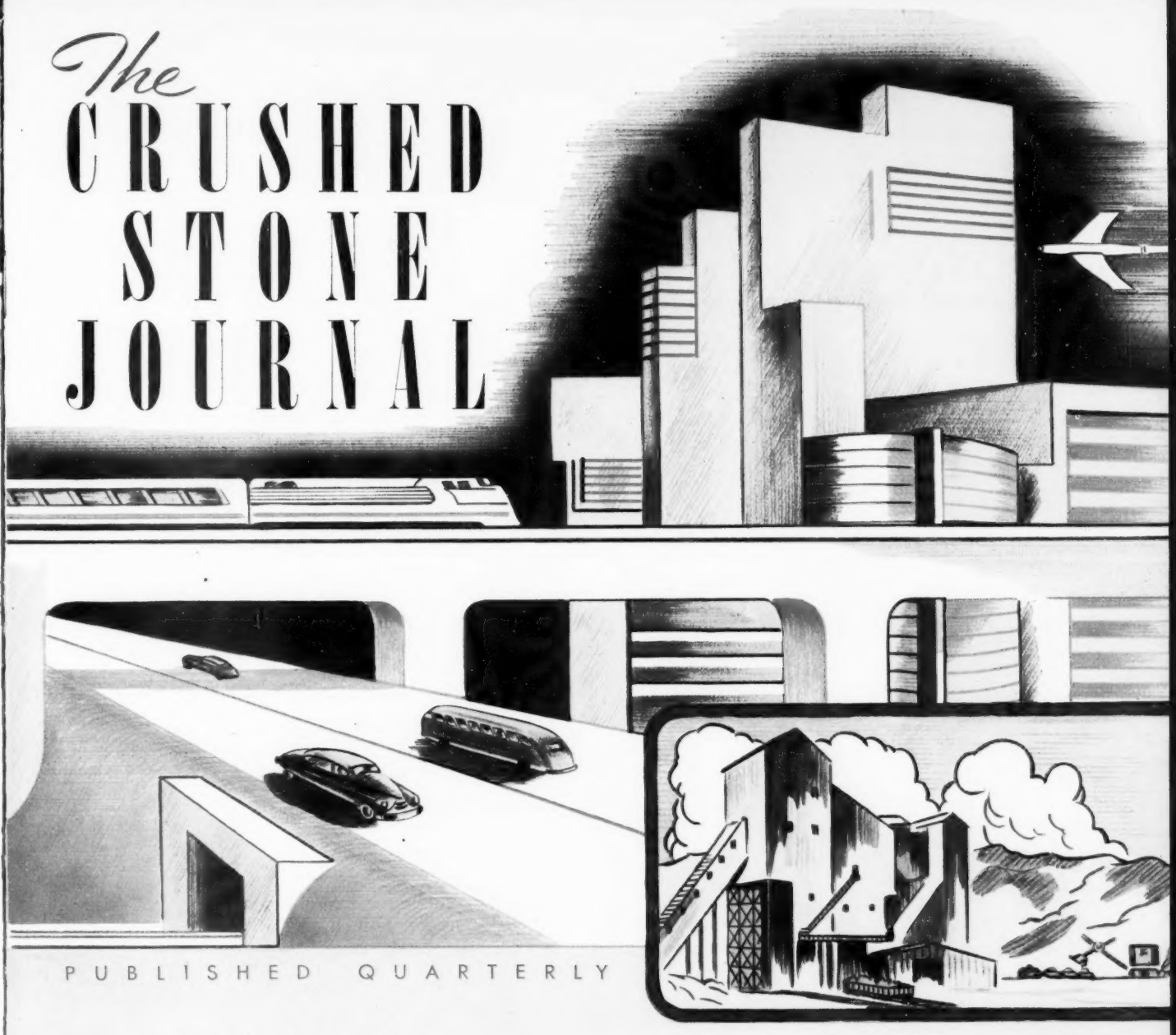
# The CRUSHED STONE JOURNAL



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In This Issue

June 1955

- Penetration Macadam Shoulders on the Ohio Turnpike
- Human Response to Blast Produced Vibrations
- Crushed and Broken Stone in 1953

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# The Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

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THE
CRUSHED STONE JOURNAL
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# Penetration Macadam Shoulders on the Ohio Turnpike

By JOSEPH E. GRAY
Field Engineer
National Crushed Stone Association
Washington, D. C.

## Introduction

PROBABLY no phase of road building is more controversial than the design of the shoulders. This is true because one sees so many miles of pavement with shoulders that are badly rutted or poorly maintained, that do not properly convey the surface run-off to the ditches or support the occasional heavy traffic loads. Such conditions shorten the useful life of the pavement and present a hazard to safe driving. The controversial nature of the problem is found in determining the proper balance among the factors to be considered, such as stability, load supporting capacity, imperviousness, safety, life, maintenance, and cost. It seems that in stretching the highway dollar, shoulder construction has borne the brunt of the economies effected. What appears to be an outstanding example of good balance in highway design, especially with respect to shoulder construction, is being carried out on the Ohio Turnpike.

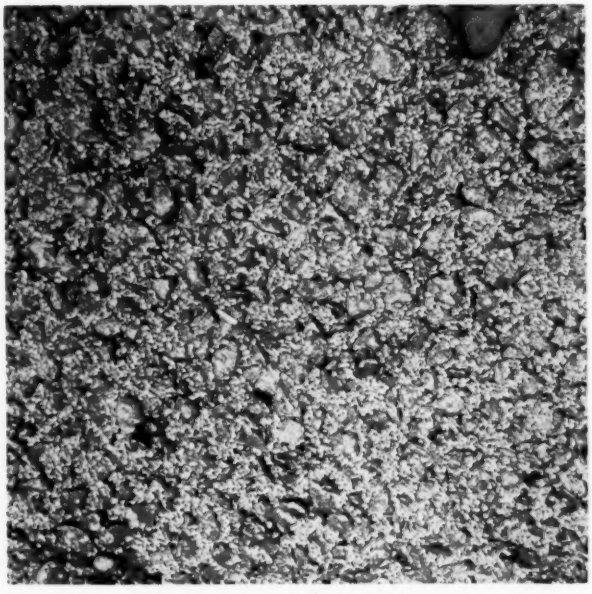
The Ohio Turnpike has been designed as a four lane divided highway. Each roadway consists of 10 in. of portland cement concrete, 24 ft wide with a 10 ft shoulder on the outside and an 8 ft shoulder on the inside or median strip. The concrete is placed on a 6 in. granular sub-base which extends through the shoulders to provide for drainage. At the edges of the pavement, the granular sub-base is built up to within 3 in. of the top and slopes to the ditches at the rate of 3/4 in. per ft. Upon this sub-base a 3 in. penetration macadam shoulder is built.

A natural inquiry would be: Why was penetration macadam selected for the construction of these shoulders? In answer to this question there are several reasons: (1) a shoulder had to be built that could be used by all traffic even though it might be used infrequently; (2) a shoulder had to be provided that would occasionally support very heavy loads; (3) a shoulder had to be constructed that would safely, yet almost automatically, let the traveling public know when their vehicle was off of the pavement and on the shoulder; (4) a most durable type of shoulder had to be built.

Penetration macadam, when built on a stable base, permits vehicles to move safely over its surface, yet a driver immediately feels and often hears when his vehicle has moved off of the concrete roadway on to the macadam shoulder. Since penetration macadam involves the use of bituminous material in thick films, it is the most durable, that is, it has the longest life of all bituminous road surfaces, when subjected to very light traffic.

The construction of a shoulder with any material that provides an impervious surface accomplishes several objectives which are important to the life and service of the road. Naturally, a watertight surface facilitates the complete removal of all surface water without a softening of the shoulder and the resulting loss of load support. The subgrade under the shoulder has less fluctuation in moisture content and thereby has more uniform bearing power. Yet, the greatest benefit probably accrues to the portland cement concrete pavement itself. Under conditions of prolonged drought there is a loss of moisture in the subgrade which decreases inward from the edge of the impervious surface for a distance of several feet, but rarely more than 6 ft. In the past,

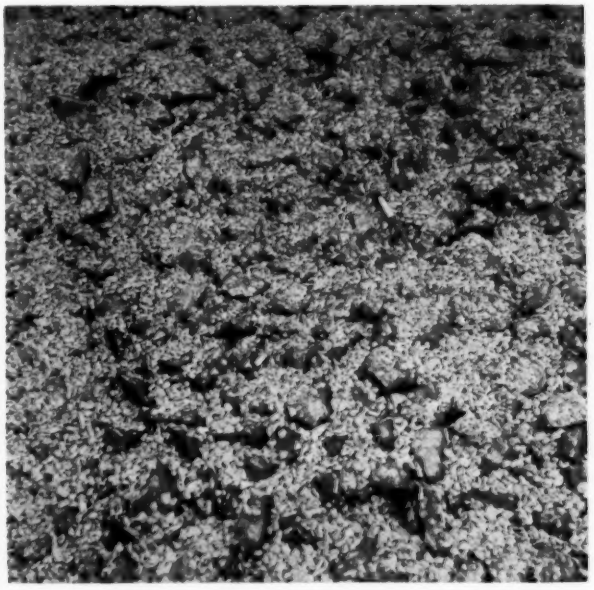
Rolled Coarse Stone (1 1/2 to 2 1/2 in.)



Initial Application of Choke Stone (3/8 in. to No. 8)

some concrete pavements have developed extensive longitudinal cracks about 4 or 5 ft from the edge due to loss of subgrade support which was caused by loss of moisture, and the resulting shrinkage of the subgrade soil. These penetration macadam shoulders as constructed on the Ohio Turnpike, being at least 8 ft wide, should move all detrimental fluctuations in subgrade moisture content beyond

Close-up of Rolled Coarse Stone



Second Application of Choke Stone (3/8 in. to No. 8)

Final Seal (3/8 in. to No. 8)

the pavement itself, and thereby provide for uniform subgrade support of the pavement.

The granular sub-base which is under the portland cement concrete roadway is extended and increased in thickness to form the base for the macadam shoulders. The specification requirements for this material are as follows:

Gradation:

| *Sieve opening* | *Total Per Cent Passing* |
|---|---|
| 3 in. | 100 |
| 1 1/2 in. | 70–100 |
| 3/8 in. | 40–100 |
| No. 10 | 20–75 |
| No. 40 | 10–35 |
| No. 200 | 0–15 |

Material passing the 40 mesh sieve shall have a plasticity index of not more than 3 and a liquid limit of not more than 20. On many sections of the Turnpike this sub-base material consists essentially of crusher-run stone. The subgrade is finished with a slope of 3/16 in. per ft and the shoulders are finished with a 3/4 in. slope per ft, so the thickness of granular base under a 10 ft shoulder is 13 in. next to the pavement and about 5 1/2 in. at the outside edge. This base material for the shoulders is placed in two courses and thoroughly rolled. It is not primed prior to placing the macadam course.

The macadam course consists of the application of 270 lb per sq yd of No. 2 stone, of which the gradation requirements are as follows:

| *Sieve opening* | *Total Per Cent Passing* |
|---|---|
| 3 in. | 100 |
| 2 1/2 in. | 90–100 |
| 2 in. | 35–70 |
| 1 1/2 in. | 0–15 |

The stone is rolled with a 10 ton roller until it does not move and the compaction is complete with the stone well interlocked. When tested with a 10 ft straight-edge there must not be any depression greater than 3/8 in.

Asphalt of 85-100 penetration grade is applied to the compacted stone at the rate of 1.1 gal per sq yd. The temperature of the asphalt is within the range of 300 to 350 F and if it is above 375 F it is rejected.

Immediately following the application of the asphalt, the surface is choked with No. 6 stone at the rate of 25 lb per sq yd. The gradation of No. 6 stone is as follows:

| *Sieve opening* | *Total Per Cent Passing* |
|---|---|
| 1/2 in. | 100 |
| 3/8 in. | 90–100 |
| No. 4 | 10–35 |
| No. 8 | 0–5 |

Self-propelled, Side-delivery Stone Spreader Places Coarse Stone on Shoulder

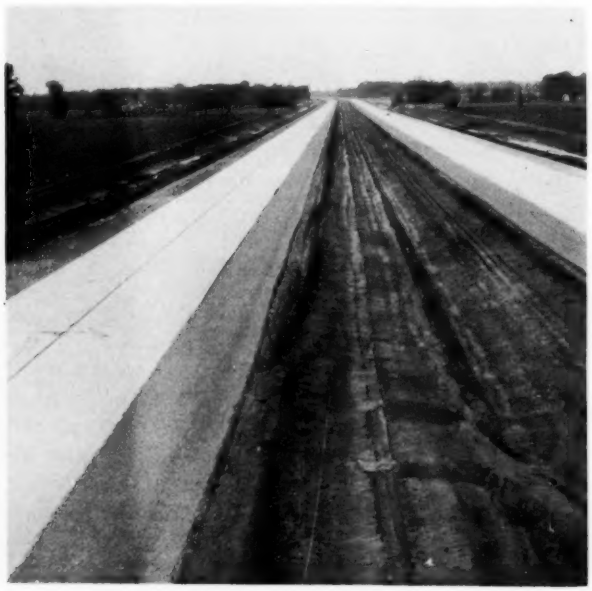
Large 3-Wheel Roller With Wire Broom Drag Distributes and Rolls Seal Coat

Finished Shoulder

Rolling of the choke stone is the next operation. This is done while the asphalt is tacky and not set or cured to the point that it is brittle.

A second application of hot asphalt is now made at the rate of 0.9 gal per sq yd, which is followed by a second application of No. 6 choke stone at the rate of 15 lb per sq yd.

The Granular Sub-base Extends Through the Shoulders



Finished Pavement

The course is again rolled.

A final application of asphalt of MC-5 grade is made at the rate of 0.4 gal per sq yd. This is covered with No. 6 stone at the rate of 20 lb per sq yd.

The surface is then thoroughly rolled.

In summation, this 3 in. penetration macadam course consists of the application of 270 lb of No. 2 stone and 60 lb of No. 6 stone, for a total of 330 lb per sq yd treated with 2.0 gal of 85-100 penetration asphalt and 0.4 gal of MC-5 cut-back asphalt, for a total of 2.4 gal per sq yd.

The shoulders for one mile of Turnpike consisting of two 10 ft widths and two 8 ft widths, 3 in. thick, require

2,851 tons of No. 2 stone
634 tons of No. 6 stone
Total = 3,485 tons of stone

42,240 gal of 85-100 penetration asphalt
8,448 gal of MC-5
Total = 50,688 gal of asphalt

This is probably the largest project of penetration macadam shoulders that has ever been constructed; it is 241 miles long and 36 ft wide. From the history of past performance of penetration macadam, these shoulders should perform with satisfaction for many years to come.

Acknowledgment is made of the helpful assistance of Messrs. J. T. Kirkby, Secretary, and J. C. Fisher, Superintendent, for the S. E. Johnson Company of Maumee, Ohio, on whose contract the photographs were taken.

## Highway Receipts Quadrupled Since '45

MORE than four times as much money was raised for highways in 1954 than in 1945, according to a report covering a decade of highway finance. The report, prepared by the U. S. Bureau of Public Roads, states that while contributions from all sources have increased materially during the period, the quadrupling of total receipts can be attributed chiefly to the increases from state highway-user imposts and borrowings.

State highway use tax revenues continue to grow at a rapid rate, with the $3,268 million from this source in 1954 being 11 per cent over 1953 totals. Highway use taxes at all governmental levels accounted for $3,318 million last year, or 60 per cent of total revenue for highways, exclusive of borrowings, the report states.

The outstanding development of the post-war highway picture, says the report, is the "unprecedented expansion in the credit financing of the highway construction program." In 1954, borrowing on the state level, including toll road and special authorities, amounted to $2,387 million. Toll facility construction accounted for $2,100 million of this total.

During the 10-year period, more than $8,000 million of original highway and street bonds were issued: $5,800 million by the states; $1,500 million by urban places; and $800 million by the county and local rural units. Approximately $4,500 million of these bonds were for construction of toll facilities.

Highway disbursements, which exceeded $6,000 million for the first time in 1954, show the greatest increase in the amounts for capital outlay (construction and costs of rights-of-way). Of the $6,280 million in direct expenditures during the year, $3,856 million was accounted for by capital outlays, or 61 per cent. Maintenance expenditures totalled $1,780 million, or 28 per cent, with administration, highway police and interest making up the remainder. A total of $341 million was disbursed for retirement of obligations.

The report points out that the "impact of these extremely large expenditures must be viewed in the light of increased costs, however." Since 1945, the highway construction dollar has decreased in purchasing power to where it now takes $211.10 to do what $100.00 would do in 1940 (the base in the report). In 1945, $152.20 would suffice.

Maintenance and operation costs have likewise increased, and in 1954, the index stood at 228.1, with 1940 equalling 100.

Based on these data, the BPR report shows that on a 1940 base, capital outlay amounted to $1,328 million; and maintenance, $290 million in 1954. Even on this reduced magnitude, the increase in capital outlays over the 10-year period amounted to 650 per cent.

The National Highway Users Conference has incorporated these data into a report covering practically the entire modern history of highway finance. Entitled "Highway Revenues and Expenditures, 1921-1954," the report is available on request to NHUC, 966 National Press Building, Washington 4, D. C.

# Human Response to Blast Produced Vibrations*

By JULES JENKINS
President
Vibration Measurement Engineers
Chicago, Ill.

ONE of the basic tenets of advertising is that the power of suggestion is all powerful. Advertising is to make known and communicate ideas—the more often repeated the more believed and longer remembered. This tenet is not new—it dates back to antiquity. "Carthage, methinks, must utterly be destroyed." That quotation was made by the Roman, Marcus Cato, over 2,000 years ago. (234-149 B. C.) Cato proclaimed this idea until he achieved his goal—the utter destruction of Carthage.

Fish is still regarded as a "brain food" when all dietitians know that it has no such exclusive virtue. Spinach is still stuffed into thousands of protesting kids in spite of the fact there are many other much more palatable vegetables which are just as nourishing. Millions of people still will not eat oysters in a month that does not contain the letter "R" in its spelling despite the findings of frozen food research. The lasting qualities of catch phrase slogans firmly implanted in the public mind has long been recognized.

What has all this to do with Human Response to Blast Produced Vibrations? Just this—like the false ideas we have related, like the old wives' tales, that have been handed down through generations, persons subjected to the vibrational effects of blasting have developed a formidable array of false beliefs which have become firmly implanted and widely accepted by persistent and repeated telling: "The doors and windows rattled and you can't tell me this won't damage the house." "We are on a rock vein and every time they blast we get the brunt of it." "It was just like an earthquake." "This house was built by a contractor for his own use and he only put the best of materials and workmanship into it."

These are but a few of the misconceptions which are held by the public. They are the carry-over of years which will continue despite denials by individual operators and users of commercial explosives. It is going to take a lot of persistent and widespread education on association levels, if you please, to change the public mind. Of this we can be certain.

The time has arrived when the crushed stone industry must give earnest consideration to embarking upon a comprehensive program of public relations. Legislative trends presently sweeping the country, are strongly influenced by lay thinking. Many of the proposed regulations are predicated upon the misconceptions we have outlined. Once they are adopted, many operators may suddenly find themselves confronted with restrictions that would materially curtail their blasting operations to the point of hardship,—yes, even to the point of complete shutdown. The industry might well adopt the slogan, "Let us discipline ourselves before we are disciplined by others."

The products and by-products of the crushed stone industry constitute vital contributions to the comforts and benefits which make up the American way. Why not start by firmly implanting these benefits in the public mind?

By and large, persons inexperienced in the use of commercial explosives are possessed of the fixed opinion that explosives in any form are agents of destruction. These opinions are understandable since the public, especially during the past decade, have been subjected to an endless flow of propaganda, employing the repetition technique, calculated to impress upon them the tremendous destructive potentials of "A" and "H" bombs and other military explosives. It is only natural that people conclude from this constant indoctrination, that the commercial dynamites present the same destructive potentials. The fact they do not take into consideration is that the military explosives are especially designed to create widespread havoc and destruction, whereas, the commercial dynamites are engineered to perform work.

They do not know that several hundred grades of commercial explosives have been developed for

*Presented at the 38th Annual Convention of the National Crushed Stone Association held at the Netherland Plaza, Cincinnati, Ohio, February 7-9, 1955

specific applications. They do not know that several hundred million pounds of these "working explosives" are annually consumed in tasks vital to our daily existence. They are not aware that the sand which produced the glass through which the morning sun shone to awaken them, was torn from the breast of Mother Earth by dynamite. They are acutely aware of the need for vitamins in their daily diets—another product of repetitious advertising—yet few persons, indeed, are aware of the fact that the vitamins they consume in their morning cereals were fused into these foods by the use of agricultural limestone which came into being through the forces of dynamite.

They seldom think that the ores which provide the metals used to fabricate the vehicles in which they ride to their appointed daily tasks, or the concrete highways over which they travel, owe their existence to dynamite. So on, throughout each day, the public pays scant heed to the countless comforts they enjoy, all made possible by dynamite. On the other hand, the public is not possessed of similar ideas about gasoline or illuminating gas, yet these commodities are from 8 to 80 times more powerful than are equal quantities of commercial dynamites. People know from personal experience that these "domesticated explosives" have been harnessed to motor propelled vehicles and piped in safety to the family gas range; hence, they take them for granted. They do not know that when properly used, the behavior of commercial dynamites can be controlled in much the same manner and with equal safety.

All of this leads to the interesting conjecture—Why do persons, and particularly persons of good repute, resort to the exaggerated and fantastic descriptions they employ? It is becoming increasingly manifest, that the answer to this question will not be forthcoming until more is known about human response to impact forces.

Up to the present time, seismology as adapted to commercial blasting operations, has been almost entirely confined to interpreting blast produced vibrations in terms of damage to structures. In the course of these investigations, scientists, physicists, and engineers, have been constantly alert to the wide discrepancies between reported vibration intensities based upon human reactions, and the actual intensity of the same phenomena as determined by instrumental measurement. The problem is not confined to blasting vibrations alone but extends from all types of low frequency oscillatory motion up through the field of supersonics.

It was early recognized that the problem of human response to vibration was one that extended into the fields of physiology and psychology. However, vibration investigators to date have shied from straying into other fields which they consider to be outside the scope of their professional activity. Nevertheless, we are at the point where someone must lead the way even at the risk of being accused of trespass into these other fields.

When we review the work that has been done in human reaction to vibration, we find that the investigations are largely confined to steady state motion, that they have been primarily concerned with product effects—the riding qualities in vehicles, vibration in ship structures and aircraft, just to name a few. At first reading the published reports are seemingly contradictory and confusing. Upon further study, however, each premise is found to have merit within the limits investigated.

Unfortunately, aside from the fact they provide valuable knowledge concerning human reaction to constant agitation, the data is mute with respect to transient or impact forces such as occur as the result of an embedded dynamite blast. They do, however, disclose interesting trends which undoubtedly will play important roles in the impact investigations of the future.

The work of the Germans, Reiher and Meister, undertaken at the Institute of Technology, Stuttgart, in 1931 and 1935, provide some important clues in this direction. These men subjected a group of 15 persons, 25 to 40 years of age, to the continuous oscillations of a vibratory platform, through amplitudes ranging from 4 ten thousandths of an inch to 4 in. at frequencies of from 1 to 70 cycles per second. This amplitude-frequency range corresponds in general to that of the great majority of routine blasts both in quarries and underground mines. They exposed each subject to various vibrational modes for 8 min test intervals, and extended the tests to include both vertical and horizontal motion, during which the subject was standing or reclining. In the reclining positions, motion was applied parallel and transverse to the axis of the body. Following each test the sensations experienced by the subjects were rated as (1) Not Noticeable, (2) Barely Noticeable, (3) Well Noticeable, (4) Strongly Noticeable, (5) Objectionable, (6) Uncomfortable. Thus, between categories 1 and 3, the

threshold of irritation was established, and between categories 4 and 6 the threshold of discomfort.

As was expected, the degree of sensation varied widely between subjects. Furthermore, the same sensation was not always experienced by the same person reacting to identical vibratory motion. Even so, the test results were carefully plotted and a wealth of valuable data obtained. Time does not permit more than a limited review of this data which we have condensed into five graphic illustrations. In these graphs we have only produced the curves of categories 2, 4, and 6, namely, Perceptible, Objectionable, and Uncomfortable.

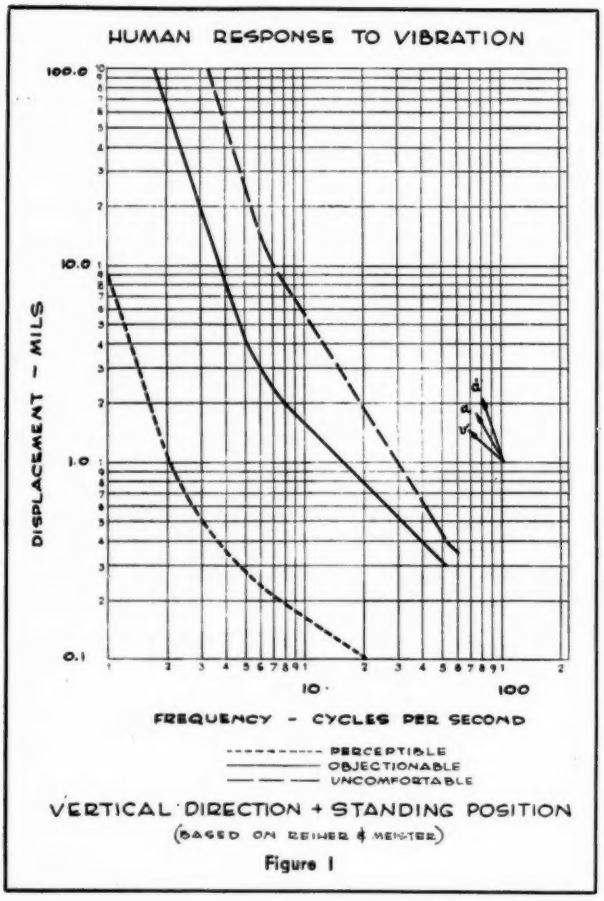



Figure 1

In Figure 1 we shall confine our discussion of amplitudes to a frequency of 10 cycles per second, hence, if you will concentrate your attention upon the vertical coordinate over the figure 10 at the bottom center of each graph, you will follow our remarks with ease. The horizontal lines indicate the vibration amplitudes in mils, thousandths of an inch; the vertical lines, the frequency in cycles per second. The short-dash curve represents Perceptibility, the solid curve Objectionable, the long-dash curve, Uncomfortable. On the right you will observe a cluster of three arrows which represent three vibrational characteristics, namely, velocity, acceleration, and rate of change of acceleration, sometimes referred to as "jerk." When the slope of the curve corresponds to the direction of an arrow, it indicates that the human sensations in this section of the curve are reacting to the character-

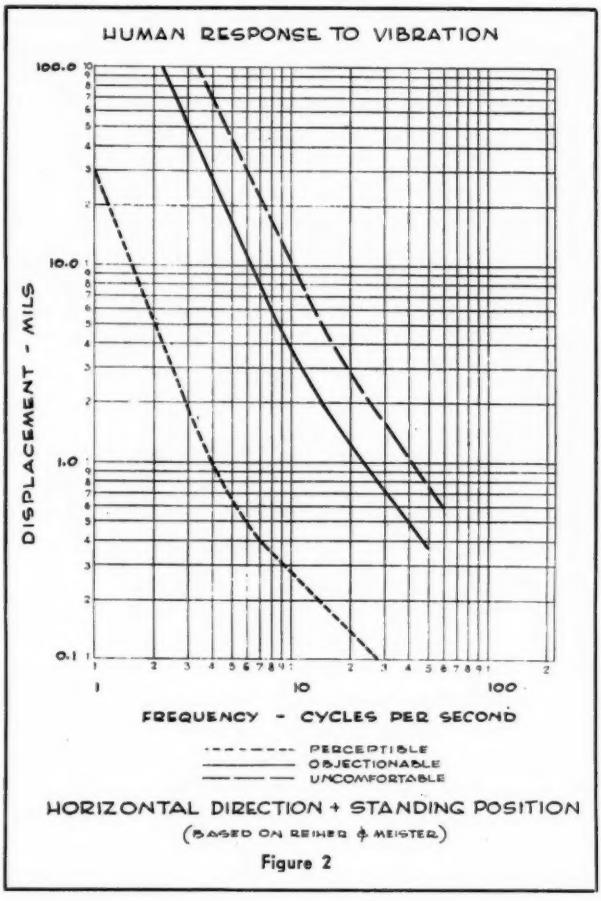



Figure 2

istics of the vibration indicated by the arrow. This tells us generally, that in the lower frequencies (below 5 cycles) the reaction tends to conform to the "rate of change in acceleration," in the middle fre-

quencies (5 to 10 cycles) to "acceleration," and in the higher frequencies (above 10 cycles) to "velocity."

In this case (at 10 cycles) the effect of vertical movement applied to a person standing must be increased 9 times over Perceptibility before becoming Objectionable and 32 times before becoming Uncomfortable. The difference between Objectionable and Uncomfortable represents a 3.5 time increase.

In Figure 2 the person remains standing while being subjected to horizontal movement; in this case the motion must be increased 13 times over Perceptibility to become Objectionable and 39 times to be Uncomfortable. The difference between the

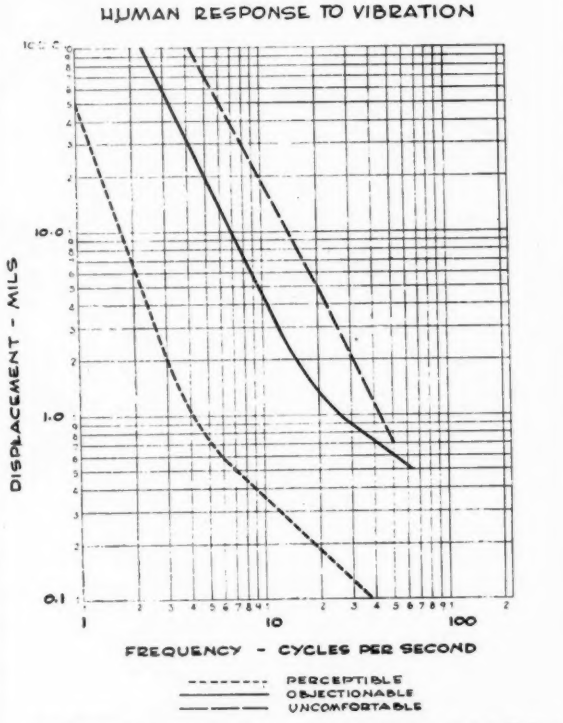



Figure 3

Objectionable-Uncomfortable limits is 3 times—approximately the same differential as that for vertical movement. In general, when standing, it takes twice as much horizontal movement than it does vertical movement to invade the Objectionable-Uncomfortable limits.

In Figure 3 the subject is now in a reclining position and moved in the vertical direction. Here it

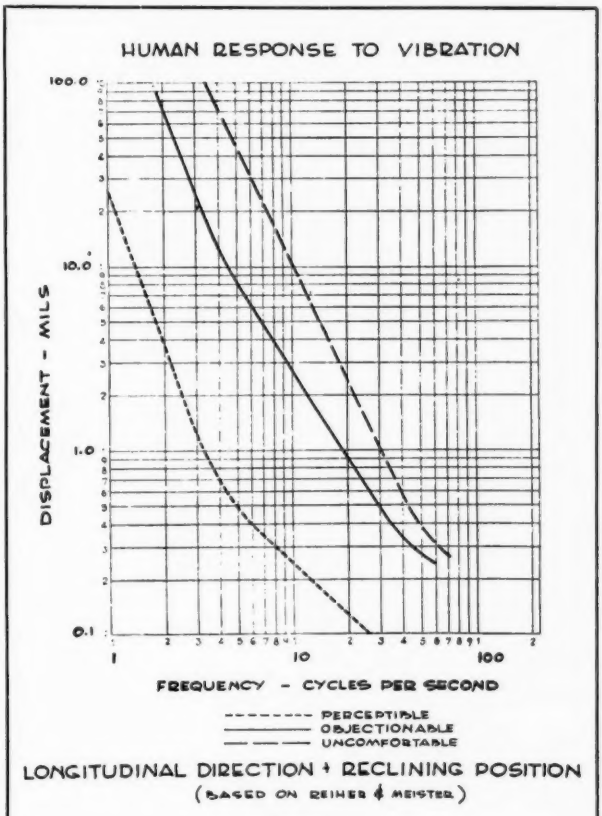



Figure 4

requires a 13 time increase over Perceptibility to become Objectionable and a 51 time increase to be Uncomfortable. When we compare this with Figure 1 (vertical-standing) we find that it takes 3 times as much motion to invade the Objectionable-Uncomfortable limits, in other words, the body is more sensitive to vertical vibration when standing.

In Figure 4, with the subject still reclining and being moved horizontally, parallel to the axis of the body, the reaction is essentially similar to that for horizontal-standing.

In Figure 5, still in a reclining position, the movement now is transverse to the body axis. The human reaction to this agitation is the most pronounced of

the various combinations, except for the vertical standing condition.

In summary, Figure 6, the human body under steady state agitation is most sensitive to vertical

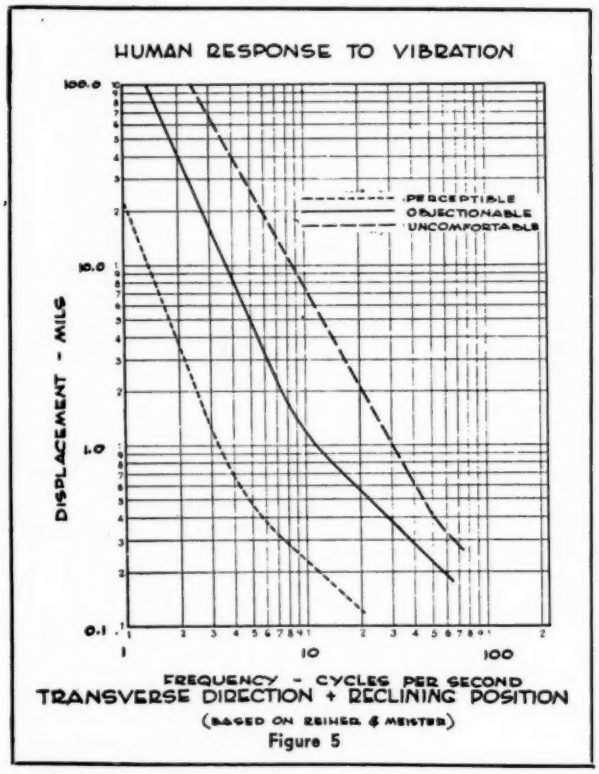


Figure 5

motion when the subject is standing, and least sensitive when reclining—as shown in the top diagram of this slide.

When the movement is confined to the horizontal direction, the reclining body is most sensitive to motion applied transverse to the body axis as is shown in the bottom diagram. Sensations of this kind are experienced in sleeping cars of trains.

Finally, while we have confined these discussions to a motion of 10 cycles per second, we must not overlook the importance of frequency upon these human reactions. For example, referring again to Figure 5, if the frequency were increased 6 times to 60 cycles, the Objectionable sensations would be experienced at an amplitude of .19 mils, or about 2 ten thousandths of an inch. This is 1/6 of the motion considered to be Objectionable at 10 cycles. Furthermore, this Objectionable motion at 60 cycles would not be felt at 10 cycles. Now, if we decrease the frequency to 5 cycles, the Objectionable sensation would not be experienced until the amplitude reached 5 mils, or 4 times the motion considered Objectionable at 10 cycles.

If we extend these curves to the upper left and beyond the limits of the graph, into the range of earthquake frequencies, it would require amplitudes of the order of inches to produce the same degree of human sensation experienced by amplitudes of less than one thousandth of an inch in the blast frequency range. This seemingly offers some explanation concerning the lay claim "it was worse than an earthquake."

One important phase of human response, not covered by Reiher and Meister, has to do with what is called the "Startle Effect." This reaction, in-

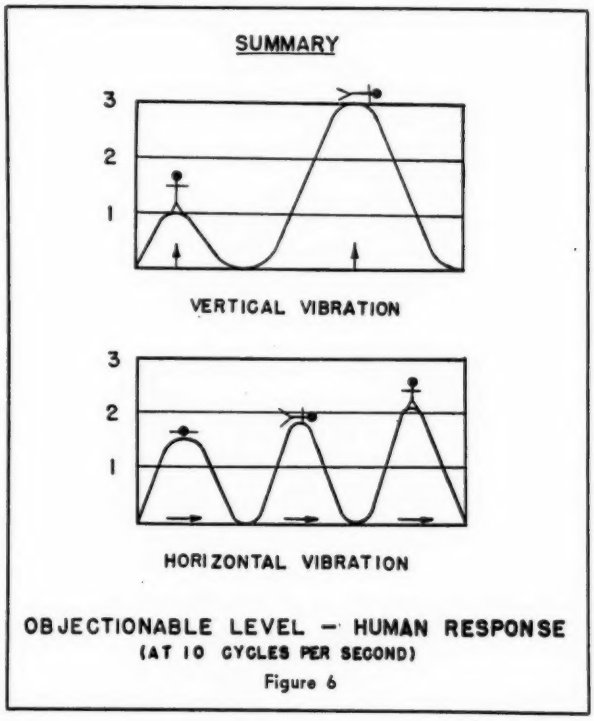


Figure 6

duced by our hearing apparatus is known to bring about momentary increases in heart rate and respiration. The source need not be long or intense, it need be unexpected only. It is well established that these sudden disturbances exert a profound influence in our decision that we detest a certain

noise, and incidentally also those responsible for making it.

The ear is not the only organ involved. Skin areas, muscles, tendons, joints, and internal organs are excited as well. The individual or collective effects on these parts of the body frequently cause persons to conclude that the earth or building supporting them is shaking violently when, as a matter of fact, they are actually being moved through microscopic dimensions.

We must remember that the average person can feel vibrations that are from one hundredth to one thousandth part of the magnitude necessary to damage structures. Until these facts are firmly implanted in the public mind, and repeated often enough, problems associated with human response to blast produced vibrations will continue to be acute.

While the facts we have related point to the road ahead, they do not in themselves hold any immediate application to quarry blasting procedures. They do, however, clearly disclose the urgent need for further investigations into the complexities of human reaction to impact. There is every reason to believe that the body can withstand a greater degree of shock under impact than it can under prolonged agitation. The photo-flash bulb only causes a momentary flutter of the eyelids, yet, were a light of equal intensity shined directly into a person's eyes but for a few seconds, prolonged discomfort would result. Everyone, at some time or other, has had occasion to move a hot pan or object from one place to another. If accomplished quickly, the heat transferred to the body, only produces a slight stinging sensation which rapidly terminates. If such object were handled with a firm grasp, a severe burn would quite likely result. We could relate other analogies; however, the two we have mentioned serve to illustrate our point.

We have made an exhaustive review of our files and endeavored to correlate some of the measured seismic results with the statements we have listened to, uttered by persons whom we regard as chronic complainers. On the basis of this crude approach, we strongly suspect that blast produced vibrations might be increased as much as 5 to 10 times that of steady state motion before the Objectionable-Uncomfortable zone is invaded.

For many years, the quarry industry paid out claims for alleged blasting damage to structures. This practice continued until a group of courageous operators banded together and underwrote the initial expense of seismographic research. From the knowledge thus gained, hundreds of lawsuits have been successfully defended. We cannot rest upon these achievements. Science ever goes forward. We must take into account that while educating ourselves, the public is better informed with respect to technological advances. The youngsters of today deal in the complexities of UHF, aero-dynamics, nuclear physics, and other scientific subjects to a degree their fathers never dreamed possible. If we are to stay ahead of those who would destroy us, we must undertake the task ourselves. We cannot leave it to others. The problem cannot be solved by the individual efforts of the lone operator; it can only be accomplished through the community effort of many operators on an industry-wide basis.

We, upon whom you call to defend you in the courts of the land, in the field of blasting legislation, note these public trends with considerable concern. We deem it is our professional duty to bring these facts to your attention for such action as you see fit. It is up to you, the operators, to protect your vested interest.

*Announcing . . . .*

**6th SHORT COURSE**
**for**
**Crushed Stone Salesmen**
**to be given by the**
**NATIONAL CRUSHED STONE ASSOCIATION**
**Washington, D. C.**
**December 6, 7, 8, 9, 1955**

**Representatives of member companies and interested State and Federal Government Engineers are cordially invited to attend.**

**Details regarding the program will be announced in the near future through mimeographed releases. However, prior information, if desired, may be obtained by writing to**

**NATIONAL CRUSHED STONE ASSOCIATION**
**1415 Elliot Place, N. W.**
**Washington 7, D. C.**

# Crushed and Broken Stone in 1953*

By L. M. OTIS
NAN C. JENSEN
Under the Supervision of G. W. Josephson, Chief
Construction and Chemical Materials Branch
Minerals Division, U. S. Bureau of Mines
Washington, D. C.

THE crushed and broken stone output in 1953, as reported by producers to the Bureau of Mines, United States Department of the Interior, was 304,496,233 short tons with a value of $423,535,036. Compared with 1952, this was an increase of 2 per cent in tonnage and 3 per cent in value. Included in this total are stone sold or used for concrete aggregates, roadstone, railroad ballast, metallurgical use (flux), agricultural limestone, refractory stone, and riprap, and in various chemical and manufacturing processes. Stone used in the manufacture of open-market lime and cement, asphaltic stone, and slate used for granules and flour are not included in this total.

Crushed and broken stone used only for concrete aggregates and road construction reached 188,721,286 short tons, and constituted 62 per cent of the total, the same percentage as in 1952. Ninety per cent of the output going into these two uses was produced by commercial operators.

Stone for metallurgical purposes, the second largest use, required 13 per cent of the total 1953 production and was 17 per cent greater in tonnage than for the same use in 1952.

* Mineral Market Report, MMS. No. 2377, April 27, 1955

CRUSHED AND BROKEN STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES,[1] 1952–53, BY PRINCIPAL USES

| Use | 1952 | | | 1953 | | |
|---|---|---|---|---|---|---|
| | Short Tons | Value | | Short Tons | Value | |
| | | Total | Average | | Total | Average |
| Concrete and roadstone | [2] 187,264,075 | [2] $246,656,141 | $1.32 | 188,721,286 | $250,996,336 | $1.33 |
| Railroad ballast | 21,383,068 | 20,019,095 | .94 | 20,778,410 | 20,533,252 | .99 |
| Furnace flux [3] | 34,908,815 | 41,119,351 | 1.18 | 40,881,304 | 53,040,512 | 1.30 |
| Alkali works | 6,557,940 | 6,448,388 | .98 | 6,786,390 | 6,507,117 | .96 |
| Riprap | 8,778,585 | 11,156,047 | 1.27 | 7,733,737 | 10,052,102 | 1.30 |
| Agricultural [3] | 21,152,208 | 34,463,963 | 1.63 | 18,452,513 | 30,133,864 | 1.63 |
| Refractory stone [4] | 1,950,786 | 7,262,048 | 3.72 | 1,937,292 | 8,079,005 | 4.17 |
| Asphalt filler | 1,002,849 | 2,934,211 | 2.93 | 708,616 | 2,440,127 | 3.44 |
| Calcium carbide works | 722,729 | 762,257 | 1.05 | 764,752 | 564,165 | .74 |
| Sugar factories | 541,419 | 1,404,391 | 2.59 | 677,296 | 1,740,270 | 2.57 |
| Glass factories | 814,302 | 1,933,165 | 2.37 | 910,989 | 2,248,590 | 2.47 |
| Paper mills | 359,904 | 820,769 | 2.28 | 324,673 | 785,806 | 2.42 |
| Other uses | 14,413,170 | 34,465,234 | 2.39 | 15,818,975 | 36,413,890 | 2.30 |
| Total | [2] 299,849,850 | [2] 409,445,060 | 1.37 | 304,496,233 | 423,535,036 | 1.39 |
| Portland and natural cement (limestone and cement rock) [5] | 64,305,000 | ([6]) | ..... | 66,251,000 | ([6]) | ..... |
| Lime [7] | 16,146,000 | ([6]) | ..... | 19,348,000 | ([6]) | ..... |
| Grand total | [2] 380,301,000 | ([6]) | ..... | 390,095,000 | ([6]) | ..... |

[1] Includes Territories of the United States, possessions, and other areas administered by the United States
[2] Revised figure
[3] Limestone
[4] Ganister (sandstone), mica schist, dolomite, and soapstone
[5] Value reported as cement in chapter on Cement
[6] No value available for stone used in manufacture of cement and lime
[7] Value reported as lime in chapter on Lime

STONE [1] SOLD OR USED BY PRODUCERS IN THE UNITED STATES, 1952–53, BY STATES

| State | 1952 | | 1953 | |
|---|---|---|---|---|
| | Short Tons | Value | Short Tons | Value |
| Alabama | 3,052,150 | $7,948,410 | 4,111,889 | $8,953,656 |
| Arizona | 235,020 | 355,709 | 442,358 | 618,748 |
| Arkansas | [2] 2,967,479 | [2] 3,346,201 | 3,061,464 | 3,865,114 |
| California | 14,374,930 | 17,697,085 | [2] 14,514,180 | [2] 18,479,152 |
| Colorado | 1,708,872 | 2,566,401 | [2] 883,646 | [2] 1,741,926 |
| Connecticut | 2,837,045 | 4,101,060 | [2] 2,826,568 | [2] 4,235,327 |
| Delaware | 94,911 | 251,759 | 80,364 | 215,382 |
| Florida | 7,836,634 | 9,577,541 | [2] 9,428,959 | [2] 11,309,421 |
| Georgia | 7,141,923 | 18,114,604 | 7,121,815 | 18,758,592 |
| Idaho | [2] 1,630,034 | [2] 2,441,236 | 1,141,626 | 2,260,875 |
| Illinois | 22,334,887 | 28,326,060 | 22,938,732 | 29,736,966 |
| Indiana | 9,126,837 | 21,965,454 | 8,714,106 | 21,695,890 |
| Iowa | 9,899,404 | 13,036,726 | 10,715,078 | 13,215,352 |
| Kansas | 8,830,871 | 12,051,740 | 8,769,152 | 11,303,950 |
| Kentucky | [2] 8,817,859 | [2] 10,816,707 | [2] 7,429,505 | [2] 9,268,237 |
| Louisiana | [3] | [3] | | |
| Maine | [2] 316,874 | [2] 1,795,768 | [2] 248,501 | [2] 1,215,439 |
| Maryland | [2] 3,391,679 | [2] 6,330,443 | [2] 3,578,249 | [2] 6,275,124 |
| Massachusetts | [2] 3,355,819 | [2] 9,331,871 | 3,457,708 | 8,821,108 |
| Michigan | 17,973,685 | 15,770,816 | 21,615,686 | 17,639,525 |
| Minnesota | [2] 2,394,178 | [2] 5,498,177 | 2,270,528 | 6,587,096 |
| Mississippi | 90,000 | 103,500 | 38,000 | 43,700 |
| Missouri | 15,106,544 | 20,676,958 | [2] 13,942,531 | [2] 19,908,540 |
| Montana | [2] 690,081 | [2] 792,897 | [2] 802,735 | [2] 1,124,731 |
| Nebraska | 1,245,106 | 1,946,448 | 1,407,158 | 2,069,984 |
| Nevada | 830,712 | 1,158,608 | 1,035,568 | 1,399,529 |
| New Hampshire | 69,850 | 546,177 | 76,701 | 538,897 |
| New Jersey | 6,102,324 | 12,307,480 | 6,036,259 | 13,307,856 |
| New Mexico | [2] 317,894 | [2] 191,642 | 624,528 | 510,713 |
| New York | 16,234,549 | 25,244,245 | [2] 15,961,657 | [2] 25,250,576 |
| North Carolina | [2] 9,647,513 | [2] 14,694,698 | [2] 9,316,823 | [2] 14,424,323 |
| North Dakota | 67,064 | 4,968 | 35,031 | 2,595 |
| Ohio | [2] 24,693,189 | [2] 36,197,485 | [2] 25,784,561 | [2] 39,642,601 |
| Oklahoma | [2] 9,636,475 | [2] 8,974,334 | 8,404,483 | 7,467,247 |
| Oregon | 6,250,849 | 8,893,368 | [2] 4,939,080 | [2] 6,301,639 |
| Pennsylvania | [2] 25,609,812 | [2] 44,676,456 | [2] 26,192,607 | [2] 48,094,029 |
| Rhode Island | 168,993 | 654,782 | 161,632 | 617,096 |
| South Carolina | [2] 2,914,839 | [2] 3,881,178 | [2] 2,913,860 | [2] 3,976,370 |
| South Dakota | 1,671,187 | 4,806,882 | [2] 1,189,418 | [2] 4,996,197 |
| Tennessee | 10,377,320 | 17,652,763 | [2] 10,485,351 | [2] 16,948,053 |
| Texas | 7,604,468 | 8,664,633 | [2] 9,095,109 | [2] 8,550,320 |
| Utah | [2] 852,351 | [2] 1,123,108 | 997,330 | 1,446,594 |
| Vermont | 404,391 | 6,016,530 | 527,150 | 8,859,703 |
| Virginia | 9,670,961 | 16,969,952 | 9,091,907 | 16,258,620 |
| Washington | 4,523,234 | 5,491,525 | 4,438,259 | 5,890,849 |
| West Virginia | [2] 4,869,442 | [2] 6,826,113 | [2] 5,501,148 | [2] 8,924,411 |
| Wisconsin | 8,578,882 | 16,754,675 | 7,450,396 | 16,039,183 |
| Wyoming | 1,466,567 | 1,688,890 | 1,431,372 | 1,839,922 |
| Alaska | [3] | [3] | 47,086 | 169,711 |
| American Samoa | | | 74,750 | 16,500 |
| Canton Island | 150 | 375 | 4,200 | 8,750 |
| Guam | 948,000 | 870,000 | 2,080,650 | 5,573,169 |
| Hawaii | 705,994 | 1,545,301 | [4] 1,299,501 | [4] 2,654,358 |
| Midway Island | 7,200 | 6,000 | 204 | 638 |
| Panama Canal Zone | 86,000 | 152,000 | 171,908 | 231,752 |
| Puerto Rico | [4] 689,320 | [4] 1,807,388 | [4] 648,400 | [4] 1,237,236 |
| Virgin Islands | 12,900 | 51,900 | 10,789 | 45,853 |
| Wake Island | 4,260 | 8,000 | 11,980 | 20,615 |
| Undistributed | 1,276,668 | 3,760,797 | 873,341 | 2,938,256 |
| Total | [5] 301,746,180 | [5] 466,465,824 | 306,453,577 | 483,527,996 |

[1] Includes—1952: 1,896,330 short tons of dimension stone valued at $57,020,764; 1953: 1,957,344 tons, $59,992,950. Does not include stone used for cement or lime manufacture

[2] To avoid disclosing confidential information certain State totals are incomplete, the portion not included being combined with "Undistributed"

[3] Included with "Undistributed"

[4] Certain territory or area totals are incomplete, the portion not included being combined with "Undistributed"

[5] Revised figure

CRUSHED STONE SOLD OR USED IN THE UNITED STATES [1] IN 1953, BY METHODS OF TRANSPORTATION

| Method of Transportation | Commercial Operations | | Commercial and Non-Commercial [2] Operations | |
|---|---|---|---|---|
| | Short Tons | Per cent of Total | Short Tons | Per cent of Total |
| Truck | 140,394,555 | 50 | 165,928,001 | 54 |
| Rail | 85,086,730 | 31 | 85,086,730 | 28 |
| Waterway | 30,129,216 | 11 | 30,129,216 | 10 |
| Unspecified | 23,352,286 | 8 | 23,352,286 | 8 |
| Total | 278,962,787 | 100 | 304,496,233 | 100 |

[1] Includes Territories of the United States, possessions, and other areas administered by the United States
[2] Entire output of non-commercial operations assumed to be moved by truck

The third largest use was for railroad ballast which consumed 7 per cent of the total, the same percentage as in 1952. Limestone for agricultural purposes took 6 per cent of the 1953 total, but showed a decrease of 13 per cent in tonnage compared with 1952.

Limestone and dolomite made up 74 per cent of the total crushed and broken stone sold or used during 1953.

The following tables present some comparative statistics covering the crushed and broken stone industry for 1952 and 1953.

LIMESTONE (CRUSHED AND BROKEN STONE) SOLD OR USED BY PRODUCERS IN THE UNITED STATES,[1] 1952–53, BY USES

| Use | 1952 | | 1953 | |
|---|---|---|---|---|
| | Short Tons | Value | Short Tons | Value |
| Riprap | 4,872,450 | $6,424,388 | 4,817,990 | $6,046,8 1 |
| Fluxing stone | 34,908,815 | 41,119,351 | 40,881,304 | 53,040,512 |
| Concrete and roadstone | 127,379,148 | 163,580,762 | 130,144,412 | 165,219,773 |
| Railroad ballast | 8,827,561 | 9,389,824 | 9,722,715 | 10,698,266 |
| Agriculture | 21,152,208 | 34,463,963 | 18,452,513 | 30,133,864 |
| Alkali works | 6,557,940 | 6,448,388 | 6,786,390 | 6,507,117 |
| Calcium carbide works | 722,729 | 762,257 | 764,752 | 564,165 |
| Coal-mine dusting | 421,847 | 1,685,124 | 401,391 | 1,495,114 |
| Filler (not whiting substitute): | | | | |
| Asphalt | 1,002,849 | 2,934,211 | 708,616 | 2,440,127 |
| Fertilizer | 599,856 | 1,165,437 | 437,986 | 809,916 |
| Other | 350,359 | 1,312,562 | 296,136 | 1,087,061 |
| Filter beds | 89,025 | 145,492 | 75,951 | 135,260 |
| Glass factories | 814,302 | 1,933,165 | 910,989 | 2,248,590 |
| Limestone sand | 1,697,657 | 2,157,633 | 1,754,023 | 2,265,817 |
| Limestone whiting [2] | [3] 762,354 | [3] 7,164,895 | 635,490 | 4,387,944 |
| Magnesia works (dolomite) [4] | 433,041 | 859,151 | 353,573 | 950,786 |
| Mineral food | 549,329 | 2,963,723 | 503,779 | 2,756,447 |
| Mineral (rock) wool | 10,811 | 14,119 | 12,210 | 18,150 |
| Paper mills | 359,904 | 820,769 | 324,673 | 785,806 |
| Poultry grit | 78,866 | 603,509 | 103,075 | 648,965 |
| Refractory (dolomite) | 707,741 | 1,047,662 | 766,404 | 1,098,153 |
| Road base | 1,370,970 | 1,244,975 | 2,283,041 | 1,967,440 |
| Stucco and terrazzo | 121,192 | 1,085,853 | 104,195 | 997,266 |
| Sugar factories | 541,419 | 1,404,391 | 677,296 | 1,740,270 |
| Other uses [5] | 995,452 | 1,562,975 | 696,198 | 2,121,596 |
| Use unspecified | 1,140,872 | 1,568,586 | 1,299,607 | 1,821,924 |
| Total | 216,468,697 | 293,863,165 | 223,914,709 | 301,987,180 |

[1] Includes Hawaii and Puerto Rico
[2] Includes stone for filler for calcimine, caulking compounds, ceramics, chewing gum, explosives, floor coverings, foundry compounds, glue, grease, insecticides leather goods, paint, paper, phonograph records, picture-frame moldings, plastics, pottery, putty, roofing, rubber, tooth paste, wire coating, and unspecified uses. Excludes limestone whiting made by companies from purchased stone
[3] Includes some whiting made from by-product marble
[4] Includes stone for refractory magnesia
[5] Includes stone for acid neutralization, carbon dioxide, chemicals (unspecified), concrete blocks and pipes, dyes, electric products, fill material, magnesium metal, oil-well drilling, patching plaster, rayons, roofing granules, spalls, and water treatment

# Manufacturers Division — National Crushed Stone Association

These associate members are morally and financially aiding the Association in its efforts to protect and advance the interests of the crushed stone industry. Please give them favorable consideration whenever possible.

**Allis-Chalmers Mfg. Co.**
Milwaukee 1, Wis.
*Crushing, Screening, Washing, Grinding, Cement Machinery; Motors; Texrope Drives; Centrifugal Pumps; Tractors*

**American Cyanamid Co.**
**Explosives Department**
30 Rockefeller Plaza, New York 20, N. Y.
*Explosives and Blasting Supplies*

**American Hoist & Derrick Co.**
63 South Robert St., St. Paul 1, Minn.
*Crawler and Truck Cranes, Shovels, Draglines, and Clamshells; Locomotive and Gantry Cranes; Hoists, Derricks, and Wire Rope Clips and Fittings*

**American Manganese Steel Division**
**American Brake Shoe Co.**
109 North Wabash Ave., Chicago 2, Ill.
*Manganese and Alloy Steel Castings, Power Shovel Dippers, Material Handling Pumps, Reclamation and Hard-Facing Welding Materials*

**American Pulverizer Co.**
1249 Macklind Ave., St. Louis 10, Mo.
*Manufacturers of Ring Crushers and Hammermills for Primary and Secondary Crushing*

**American Steel & Wire Division**
Rockefeller Bldg., 614 Superior Ave., N. W., Cleveland 13, Ohio
*Wire Rope, Aerial Wire Rope Tramways, Electrical Wires and Cables, Welded Wire Fabric, Concrete Reinforcing, Wire Nails, Fencing, Netting*

**Aquadyne Corp.**
62 LaSalle Road, West Hartford, Conn.
*"Wet Water" Dust Control System*

**Atlas Powder Co.**
Wilmington 99, Del.
*Industrial Explosives and Blasting Supplies*

**Bacon-Greene & Milroy**
29 Washington Ave., Hamden 14, Conn.
*"Farrel-Bacon" Jaw Crushers for Primary and Secondary Operations, Conveyors, Elevators, Rolls, Screens*

**Baker-Lull Corp.**
314 West 90th St., Minneapolis 20, Minn.
*Shovel Loaders (Front End)*

**Baldwin-Lima-Hamilton Corp.**
**Construction Equipment Division**
South Main St., Lima, Ohio
*Power Shovels, Draglines, Cranes, Bins, Conveyors and Idlers, Crushers and Pulverizers, Feeders, Plants—Crushing and Portable, Washing Equipment*

**Barber-Greene Co.**
400 North Highland Ave., Aurora, Ill.
*Portable and Permanent Belt Conveyors, Belt Conveyor Idlers, Bucket Loaders Both Wheel and Crawler Mounted, Asphalt Mixers and Finishers, Coal Handling Machines*

**Birdsboro-Buchanan Crusher Dept.**
**Birdsboro Steel Foundry & Machine Co.**
1941 Furnace St., Birdsboro, Pa.
*Primary and Secondary Crushers and Rolls*

**Boston Woven Hose & Rubber Co.**
P. O. Box 1071, Boston 3, Mass.
*Conveyor, Elevator, and Transmission Belt; V-Belts; Air Hoses; Suction Hose*

**Brunner & Lay Rock Bit Corp.**
P. O. Box 4247, Asheville, N. C.
*Tungsten Carbide Detachable Bits, "Rock Bit" Drill Steel Inlaid with Tungsten Carbide, Carbon Hollow Drill Steel, Alloy Hollow Drill Steel*

**Bucyrus-Erie Co.**
South Milwaukee, Wis.
*Excavating, Drilling, and Material Handling Equipment*

**Buda Division**
**Allis-Chalmers Mfg. Co.**
Harvey, Ill.
*Diesel and Gasoline Engines; Material Handling Equipment; Lifting Jacks; Earth Drills and Maintenance of Way Equipment*

**Burress, J. W.**
1701 Shenandoah Ave., N. W., Roanoke, Va.
*"Air-Trac" Drill Carrier*

**Cape Ann Anchor & Forge Co.**
P.O. Box 360, Gloucester, Mass.
*"Cape Ann" Forged Steel Drop Balls*

**Caterpillar Tractor Co.**
Peoria 8, Ill.
*Track-Type Tractors, Bulldozers, Earthmoving Scrapers, Motor Graders, Heavy-Duty Off-Road Hauling Units, Diesel Engines, Diesel Electric Generating Sets, Front End Shovels, Wheel-Type Tractors*

# Manufacturers Division—National Crushed Stone Association
(continued)

**Chain Belt Co.**
P. O. Box 2022, Milwaukee 1, Wis.
*Rex Conveyors, Elevators, Feeders, Idlers, Elevator Buckets, Drive and Conveyor Chains, Sprockets, Bearings, Pillow Blocks, Power Transmission Equipment, Portable Self-Priming Pumps*

**Clark Equipment Co.**
**Construction Machinery Division**
300 Miller St., Benton Harbor, Mich.
*Truck and Crawler Excavator Cranes—3/8, 1/2, 3/4 Cu. Yd.; Tractor Shovels—15 Cu. Ft. Through 2 1/4 Cu. Yd.*

**Cleveland Rock Drill Division**
**Westinghouse Air Brake Co.**
12500 Berea Road, Cleveland 11, Ohio
*Rock and Wagon Drills; Jumbo Drill Rigs, Drifters, Stopers, Self Propelled Drill Rigs*

**Continental Gin Co.**
4500 Fifth Ave., S., Birmingham 2, Ala.
*Conveyors—Belt, Screw, Flight and Underground Mine; Elevators—Bucket and Screw; Feeders—Apron, Belt, Reciprocating, Table, and Screw; Drives—V-Belts, Chains and Sprockets, Gears and Speed Reducers*

**Contractors and Engineers**
470 Fourth Ave., New York 16, N. Y.
*Magazine of Modern Construction*

**Cross Engineering Co.**
P. O. Box 507, Carbondale, Pa.
*Cross Perforated Steel Segments, Sections, Decks, for Vibrating, Shaking, Revolving, and Other Types of Screening Equipment*

**Cummins Engine Co., Inc.**
Fifth and Union Sts., Columbus, Ind.
*Lightweight Highspeed Diesel Engines (60-600 Hp.) for: On-Highway Trucks, Off-Highway Trucks, Buses, Tractors, Earthmovers, Shovels, Cranes, Industrial and Switcher Locomotives, Air Compressors, Logging Yarders and Loaders, Oil Well Drilling Rigs, Centrifugal Pumps, Generator Sets and Power Units, Work Boats and Pleasure Craft*

**Dart Truck Co.**
2623 Oak St., Kansas City 8, Mo.
*Off Highway Trucks—End, Side, Bottom Dumps*

**Deister Machine Co.**
1933 East Wayne St., Fort Wayne 4, Ind.
*Deister Vibrating Screens, Classifiers, Washing Equipment*

**Detroit Diesel Engine Division**
**General Motors Corp.**
13400 West Outer Drive, Detroit 28, Mich.
*Light Weight, Compact 2 Cycle Diesel Engines and "Package Power" Units for All Classes of Service*

**Diamond Iron Works**
**Division Goodman Manufacturing Co.**
Halsted Street & 48th Place, Chicago 9, Ill.
*Jaw and Roll Crushers; Vibrator, Revolving, and Scrubber Screens; Drag Washers; Bucket Elevators; Belt Conveyors; Bins; Apron and Plate Feeders; Portable Gravel and Rock Crushing, Screening, and Washing Plants; Stationary Crushing, Screening, and Washing Plants; Hammermills*

**Du Pont, E. I., de Nemours & Co.**
Wilmington 98, Del.
*Explosives and Blasting Supplies*

**Dustex Corp.**
1758 Walden Ave., Buffalo 25, N. Y.
*Dust Collecting Equipment; Dust Control Systems*

**Eagle Crusher Inc.**
900 Harding Way East, Galion, Ohio
*Crushers*

**Eagle Iron Works**
129 Holcomb Ave., Des Moines 13, Iowa
*Fine Material Screw Washers—Classifiers—Dehydrators; Coarse Material Screw and Log Washers—Dewaterers; Water Scalping and Fine Material Settling Tanks; Drop Balls—Ni-Hard and Semi-Steel; "Swintek" Screen Chain Cutter Dredging Ladders*

**Easton Car & Construction Co.**
Easton, Pa.
*Off-Highway Transportation: Dump Trailers, Truck Bodies, and Cars for Mines, Quarries, and Earth Moving Projects*

**Ensign-Bickford Co.**
Simsbury, Conn.
*Primacord-Bickford Detonating Fuse and Safety Fuse*

**Euclid Division**
**General Motors Corp.**
1361 Chardon Road, Cleveland 17, Ohio
*Heavy-Duty Trucks and Dump Trailers for "Off-Highway" Hauls, Loaders for Earth Excavation, Single and Twin Engine Earth Moving Scrapers*

**Frog, Switch & Mfg. Co.**
**Manganese Steel Dept.**
Carlisle, Pa.
*Manufacturers of "Indian Brand" Manganese Steel Castings for all Types of Jaw, Gyratory, and Pulverizing Crushers; Dippers, Teeth, Treads, and Other Parts for Power Excavating Equipment; and Other Miscellaneous Manganese Steel Castings. Manufacturers and Fabricators of Railroad and Mine Frogs, Switches, and Crossings*

# Manufacturers Division—National Crushed Stone Association
(continued)

**General Electric Co.**
1 River Road, Schenectady 5, N. Y.
*Electric Motors, Controls, Locomotives, Welding Equipment, Coordinated Electric Drives for: Shovels, Drag Lines, Conveyors, Hoists, Cranes, Crushers, Screens, Etc.; Coordinated Power Generating and Distributing Systems Including Generators, Switchgear, Transformers, Cable, Cable Skids, Load Center Substations*

**Gill Rock Drill Co.**
Lebanon, Pa.
*Well Drill Tools and Supplies*

**Goodyear Tire & Rubber Co., Inc.**
Akron 16, Ohio
*Airfoam; Industrial Rubber Products—Belting (Conveyor, Elevator, Transmission), Hose (Air, Water, Steam, Suction, Miscellaneous); Chute Lining (Rubber); Rims (Truck and Tractor); Storage Batteries (Automobile, Truck, Tractor); Tires (Automobile, Truck, Off-the-Road); Tubes (Automobile, Truck, Off-the-Road, Life-Guard, Safety Tubes, Puncture Seal Tubes)*

**Gruendler Crusher and Pulverizer Co.**
2915 North Market St., St. Louis 6, Mo.
*Rock and Gravel Crushing, Screening and Washing Plants, Jaw Crushers, Roll Crushers, Hammermills, Lime Pulverizers*

**Gulf Oil Corp.**
**Gulf Refining Co.**
Gulf Bldg., Pittsburgh 19, Pa.
*Lubricating Oils, Greases, Gasoline and Diesel Fuels*

**Haiss, George, Mfg. Co., Inc.**
**Subsidiary of Pettibone Mulliken Corp.**
5720 Empire State Bldg., New York 1, N. Y.
*Bucket Loaders, Buckets, Portable and Stationary Conveyors, Car Unloaders*

**Harnischfeger Corp.**
4400 West National Ave., Milwaukee 14, Wis.
*A Complete Line of Power Excavating Equipment, Overhead Cranes, Hoists, Smootharc Welders, Welding Rod, Motors and Generators, Diesel Engines*

**HarriSteel Products Co.**
420 Lexington Ave., New York 17, N. Y.
*Woven Wire Screen Cloth*

**Hayward Co.**
50 Church St., New York 7, N. Y.
*Orange Peel Buckets, Clam Shell Buckets, Electric Motor Buckets, Automatic Take-up Reels*

**Heidenreich, E. Lee, Jr.**
**Consulting Engineers**
75 Second St., Newburgh, N. Y.
*Plant Layout, Design, Supervision; Open Pit Quarry Surveys; Appraisals—Plant and Property*

**Hendrick Mfg. Co.**
Carbondale, Pa.
*Perforated Metal Screens, Perforated Plates for Vibrating, Shaking, and Revolving Screens; Elevator Buckets; Test Screens; Wedge Slot Screens; Open Steel Floor Grating*

**Hercules Powder Co.**
Wilmington 99, Del.
*Explosives and Blasting Supplies*

**Hetherington & Berner Inc.**
701-745 Kentucky Ave., Indianapolis 7, Ind.
*Asphalt Paving Machinery, Sand and Stone Dryers*

**Hewitt-Robins Incorporated**
666 Glenbrook Road, Stamford, Conn.
*Belt Conveyors (Belting and Machinery); Belt and Bucket Elevators; Car Shakeouts; Feeders; Industrial Hose; Screen Cloth; Sectional Conveyors; Skip Hoists; Stackers; Transmission Belting; Vibrating Conveyors, Feeders, and Screens; Design and Construction of Complete Plants*

**Hoyt Wire Cloth Co.**
Abraso St., P. O. Box 22, Lancaster, Pa.
*Aggregate Wire Screens Made of Supertough and Abraso Wire—Smoothtop, Longslot, Oblong Space and Double Crimp Construction—For All Makes of Vibrators*

**Hughes Tool Co.**
P. O. Box 2539, Houston 1, Texas
*Bits—Rock*

**Illinois Powder Mfg. Co.**
506 Olive St., St. Louis 1, Mo.
*Gold Medal Explosives*

**Ingersoll-Rand Co.**
11 Broadway, New York 4, N. Y.
*Rock Drills, Paving Breakers, Paving Breaker Tools and Accessories, Quarrymaster Drills, Drillmasters, Carset Bits, Jackbits, Bit Reconditioning Equipment, Portable and Stationary Air Compressors, Air Hoists, Slusher Hoists, Pneumatic Tools, Centrifugal Pumps, Diesel and Gas Engines*

**Insley Manufacturing Corp.**
801 North Olney St., Indianapolis 6, Ind.
*Concrete Carts and Buckets; 1/2 to 2 Cu. Yd. Cranes and Shovels—5 to 30 Tons Capacity—Rubber or Crawler Mounting*

**International Harvester Co.**
**Motor Truck Sales Dept.**
180 N. Michigan Ave., Chicago 1, Ill.
*Trucks, Trailers, Truck Bodies, Highway Trucks, Truck Bodies Off-Highway*

# Manufacturers Division—National Crushed Stone Association

(continued)

**Iowa Manufacturing Co.**

916 16th St., N.E., Cedar Rapids, Iowa

*Rock and Gravel Crushing, Screening, Conveying and Washing Plants, Hot and Cold Mix Asphalt Plants, Stabilizer Plants, Impact Breakers, Screens, Elevators, Conveyors, Portable and Stationary Equipment, Hammermills, Bins*

**Jaeger Machine Co.**

550 West Spring St., Columbus 16, Ohio

*Portable and Stationary Air Compressors, Self-Priming Pumps, Truck Mixers, Concrete Mixers, Road Paving Machinery, Hoists and Towers; Rubber-Tired, Front End Loaders*

**Jeffrey Manufacturing Co.**

East First Ave., Columbus 16, Ohio

*Elevator Buckets; Car Pullers; Chains; Conveyors: Belt, Drag, Apron, Vibrating; Idlers; Crushers; Pulverizers; Elevators; Feeders; Pillow Blocks; Stationary Plants; Screens*

**Johnson-March Corp.**

1724 Chestnut St., Philadelphia 3, Pa.

*Dust Control Engineers, Wet and Dry Dust Collection Systems, Gas Scrubbers*

**Joy Manufacturing Co.**

333 Henry W. Oliver Bldg., Pittsburgh 22, Pa.

*Drills: Blast-Hole, Wagon, Rock, and Core; Air Compressors: Portable, Stationary, and Semi-Portable; Aftercoolers; Portable Blowers; Carpullers; Hoists; Multi-Purpose and Portable Rock Loaders; Air Motors; Trench Diggers; Belt Conveyors; "Spaders"; "String-a-Lite" (Safety-Lighting-Cable); Backfill Tampers; Drill Bits: Rock and Core*

**Kennedy-Van Saun Mfg. & Eng. Corp.**

2 Park Ave., New York 16, N. Y.

*Crushing, Screening, Washing, Conveying, Elevating, Grinding, Complete Cement Plants, Complete Lime Plants, Complete Lightweight Aggregate Plants, Synchronous Motors, Air Activated Containers for Transportation of Pulverized Material, Cement Pumps, and Power Plant Equipment*

**Kensington Steel Co.**

505 Kensington Ave., Chicago 28, Ill.

*Oro Alloy and Manganese Steel Castings: For Shovels—Dipper Teeth, Crawler Treads, Rollers, Sprockets; For Crushers—Jaw Plates, Concaves, Mantles, Bowl Liners; For Pulverizers—Hammers, Grate Bars and Liners; For Elevators and Conveyors—Chain, Sprockets, Buckets; For Tractors—Rail Links and Grouser Plates; Drag Line Chain*

**King Powder Co., Inc.**

Cincinnati, Ohio

*Detonite, Dynamites, and Blasting Supplies*

**Koehring Co.**

3026 West Concordia Ave., Milwaukee 16, Wis.

*Excavating, Hauling, and Concrete Equipment*

**Linde Air Products Co., Division of Union Carbide and Carbon Corp.**

30 East 42nd St., New York 17, N. Y.

*Oxygen, Acetylene, Welding and Jet Piercing Equipment and Supplies*

**Link-Belt Co.**

300 West Pershing Road, Chicago 9, Ill.

*Complete Stone Preparation Plants; Conveyors, Elevators, Screens, Washing Equipment, Speed-O-Matic Shovels—Cranes—Draglines and Power Transmission Equipment*

**Link-Belt Speeder Corp.**

1201 Sixth St., S. W., Cedar Rapids, Iowa

*Complete Line of Power Hydraulically Controlled Cranes, Shovels, Trench Hoes, Draglines, Clamshells, 1/2 to 3 Yd. Capacities. Available on Crawler Base or Rubber Tire Mounting*

**Lippmann Engineering Works**

4603 W. Mitchell St., Milwaukee 14, Wis.

*Primary and Secondary Rock Crushers and Auxiliary Equipment such as Feeders, Screens, Conveyors, Etc., Portable and Stationary Crushing and Washing Plants*

**Ludlow-Saylor Wire Cloth Co.**

634 South Newstead Ave., St. Louis 10, Mo.

*Woven Wire Screens and Wire Cloth of Super-Loy, Steel, and All Commercial Alloys and Metals*

**Mack Motor Truck Corp.**

350 Fifth Ave., New York 1, N. Y.

*On- and Off-Highway Trucks, Tractor-Trailers, Six-Wheelers, from 5 to 30 Tons Capacity, both Gasoline- and Diesel-Powered*

**Marion Power Shovel Co.**

Marion, Ohio

*Marion-Osgood-General — Power Shovels, Draglines, Cranes, Truck Cranes, Mobil Cranes—From 1/2 to 60 Yd.*

**McLanahan & Stone Corp.**

252 Wall St., Hollidaysburg, Pa.

*Complete Pit, Mine, and Quarry Equipment —Crushers, Washers, Screens, Feeders, Etc.*

# Manufacturers Division—National Crushed Stone Association
(continued)

**Murphy Diesel Co.**
5317 West Burnham St., Milwaukee 14, Wis.
*Engines and Power Units—90 to 246 Hp.; Generator Sets—60 to 154 Kw.; Marine Engines—90 to 225 Hp.; Dual-Fuel Engines —135 to 180 Hp.; Mechanical and Electric Power Simultaneously*

**National Container Corp. of Ohio**
**Multi-Wall Paper Bag Division**
Jaite, Ohio
*Multi-Wall Paper Bags, Sewn and Pasted Style for Packaging Lime, Cement, Plaster, Etc.*

**New York Rubber Corp.**
100 Park Ave., New York 17, N. Y.
*Conveyor Belting: Stonore, Dependable, and Cameo Grades; Transmission Belting: Silver Duck Duroflex, Soft Duck Rugged, Commercial Grade Tractor*

**Nordberg Mfg. Co.**
Milwaukee 1, Wis.
*Symons Cone and Gyratory Crushers; Gyradisc; Grinding Mills; Stone Plant and Cement Mill Machinery; Vibrating Screens and Grizzlies; Diesel Engines and Diesel Driven Generator Units; Mine Hoists; Track Maintenance Machinery*

**Northern Blower Co.**
6409 Barberton Ave., Cleveland 2, Ohio
*Dust Collecting Systems, Fans—Exhaust and Blower*

**Northwest Engineering Co.**
135 South LaSalle St., Chicago 3, Ill.
*Shovels, Cranes, Draglines, Pullshovels—Crawler and Truck Mounted*

**Pennsylvania Crusher Division**
**Bath Iron Works Corp.**
323 South Matlack St., West Chester, Pa.
*Single Roll Crushers, Impactors, Hammermills, Ring Type Granulators, Kue-Ken Jaw Crushers, Kue-Ken Gyratories, Dixie Non-Clog and Standard Hammermills*

**Pettibone Mulliken Corp.**
4710 West Division St., Chicago 51, Ill.
*Material Handling Buckets, Clamshells, Draglines, Pullshovels, Dippers, Shovel Dippers, Pumps, Hammermills, Front End Loaders, Bucket Conveyor Loaders, Fork and Bucket Loaders, Speed Swing Loaders, Speed Swing Yard Cranes, Motor Graders, Manganese Steel Castings*

**Pioneer Engineering Works, Inc.**
1515 Central Ave., N. E., Minneapolis 13, Minn.
*Jaw Crushers, Roll Crushers (Twin and Triple), Vibrating and Revolving Screens, Feeders (Mechanical, Grizzly, Apron, and Pioneer-Oro Manganese Steel), Belt Conveyors, Portable and Stationary Crushing and Screening Plants, Washing Plants, Mining Equipment, Cement and Lime Equipment, Asphalt Plants and Finishers*

**Pit and Quarry Publications, Inc.**
431 South Dearborn St., Chicago 5, Ill.
*Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Concrete Manufacturer, Concrete Industries Yearbook*

**Productive Equipment Corp.**
2926 West Lake St., Chicago 12, Ill.
*Vibrating Screens*

**Quaker Rubber Corp.**
**Division of H. K. Porter Co., Inc.**
**of Pittsburgh**
Tacony and Comly Sts., Philadelphia 24, Pa.
*Conveyor Belts, Hose, and Packing*

**Radio Corporation of America**
**Engineering Products Department**
**Industrial Equipment Section**
Front and Cooper Sts., Bldg. 15-1, Camden 2, N. J.
*Electronic Metal Detectors*

**Rock Products and Concrete Products**
309 West Jackson Blvd., Chicago 6, Ill.

**Rogers Iron Works Co.**
11th and Pearl Sts., Joplin, Mo.
*Jaw Crushers, Roll Crushers, Hammermills, Vibrating Screens, Revolving Screens and Scrubbers, Apron Feeders, Reciprocating Feeders, Roll Grizzlys, Conveyors, Elevators, Portable and Stationary Crushing and Screening Plants, Mine Hoists, Drill Jumbos and Underground Loaders*

**Screen Equipment Co., Inc.**
1754 Walden Ave., Buffalo 25, N. Y.
*Seco Vibrating Screens; Scales—Industrial, Aggregates, Truck*

**Simplicity Engineering Co.**
Durand, Mich.
*Simplicity Gyrating Screens, Horizontal Screens, Simpli-Flo Screens, Tray Type Screens, Heavy Duty Scalpers, D'Watering Wheels, D'Centegrators, Vibrating Feeders, Vibrating Pan Conveyors, Car Shake-Outs, Woven Wire Screen Cloth*

**Smith Engineering Works**
532 East Capitol Drive, Milwaukee 12, Wis.
*Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants*

# Manufacturers Division—National Crushed Stone Association
(concluded)

**Stedman Foundry & Machine Co., Inc.**

Aurora, Ind.

*Stedman Impact-Type Selective Reduction Crushers, 2-Stage Swing Hammer Limestone Pulverizers, Multi-Cage Limestone Pulverizers, Vibrating Screens*

**Stephens-Adamson Mfg. Co.**

Aurora, Ill.

*Belt Conveyors, Elevators, Feeders, Car Pullers, Screens, Skip Hoists, Complete Plants*

**Taylor-Wharton Iron & Steel Co.**

High Bridge, N. J.

*Manganese and other Special Alloy Steel and Iron Castings; Dipper Teeth, Fronts and Lips; Crawler Treads; Jaw and Cheek Plates; Mantles and Concaves; Pulverizer Hammers and Liners; Asphalt Mixer Liners and Tips; Manganese Nickel Steel Welding Rod and Plate*

**Thew Shovel Co.**

East 28th St. and Fulton Rd., Lorain, Ohio

*"Lorain" Power Shovels, Cranes, Draglines, Clamshells, Hoes, Scoop Shovels on Crawlers and Rubber-Tire Mountings. Diesel, Electric, and Gasoline, 3/8 to 2 Yd. Capacities*

**Torrington Co.**
**Bantam Bearings Division**

3702 West Sample St., South Bend 21, Ind.

*Anti-Friction Bearings; Self-Aligning Spherical, Tapered, Cylindrical, and Needle Roller; Roller Thrust; Ball Bearings*

**Travel Drill Co.**

P. O. Box 1124, Raleigh, N. C.

*"Travel Drill"—Mobile Drill for Secondary Drilling in Quarries and Open Pit Work*

**Traylor Engineering & Mfg. Co.**

Allentown, Pa.

*Stone Crushing, Gravel, Lime, and Cement Machinery*

**Trojan Powder Co.**

17 North 7th St., Allentown, Pa.

*Explosives and Blasting Supplies*

**Tyler, W. S., Co.**

3615 Superior Ave., N. E., Cleveland 14, Ohio

*Woven Wire Screens; Ty-Rock, Tyler-Niagara and Ty-Rocket (Mechanically Vibrated) Screens; Hum-mer Electric Screens; Ro-Tap Testing Sieve Shakers; Tyler Standard Screen Scale Sieves, U. S. Sieve Series*

**Unit Crane & Shovel Corp.**

6411 West Burnham St., Milwaukee 14, Wis.

*1/2 and 3/4 Cu. Yd. Crawler, Mobile and Truck Mounted Shovels, Draglines, Cranes, Clamshells, Trenchoes, and Magnets*

**Universal Engineering Corp.**

625 C Ave., N. W., Cedar Rapids, Iowa.

*Jaw Crushers, Roll Crushers, TwinDual Roll Crushers, Hammermills, Impact Breakers, Pulverizers, Bins, Conveyors, Feeders, Screens, Scrubbers. Bulldog Non-Clog Moving Breaker Plate and Stationary Breaker Plate Hammermills, Center Feed Hammermills. A Complete Line of Stationary and Portable Crushing, Screening, Washing, and Loading Equipment for Rock, Gravel, Sand, and Ore. Aglime Plants. Asphalt Plants*

**Vibration Measurement Engineers**

7665 Sheridan Road, Chicago 26, Ill.

*Seismographic and Airblast Measurements, Seismological Engineering, Blasting Complaint Investigations, Expert Testimony in Blasting Litigation; Nation-wide Coverage*

**Werco Steel Co.**

2151 East 83rd St., Chicago 17, Ill.

*Castings—Manganese, Alloy Steel; Screen Plates—Perforated Steel Screen Sections and Decks; Buckets; Chains; Belt Conveyors, Idlers; Dipper—Shovel; Drop Balls; Wire Cloth; Wire Rope and Related Products*

**Weston Dump Body Co.**

326 S.W. 11th St., Des Moines 9, Iowa

*Combination Lime, Sand, and Gravel Body; Special Bodies for Quarry and Pit Work*

**White Motor Co.**

842 East 79th St., Cleveland 1, Ohio

*On- and Off-Highway Trucks and Tractors—Gasoline- and Diesel-Powered; Industrial Engines, Power Units, Axles, Special Machine Assemblies; All Classes of Service*

**Williams Patent Crusher & Pulverizer Co.**

2701-2723 North Broadway, St. Louis 6, Mo.

*Hammer Mills, Crushers, Pulverizers, Roller Mills, Reversible Impactors, and Vibrating Screens*